

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION
Thirty Van Ness Avenue, San Francisco 94102 557 - 3686

March 28, 1986

TO: All Commissioners and Alternates
FROM: Alan R. Pendleton, Executive Director
SUBJECT: ACCELERATED SEA LEVEL RISE IN SAN FRANCISCO BAY
(For Commission information only)

As part of its 1985-1986 planning work program, the Commission instructed the staff to investigate the potential impacts in San Francisco Bay from a possible rise in sea level. This sea level rise has been predicted by many scientists, including the federal Environmental Protection Agency (see the attached New York Times article). The staff requested the Commission's consultant on hydrology and tidal hydraulics, Dr. Philip Williams, to review the existing literature concerning the accelerated sea level rise, to indicate the implications of this phenomenon for San Francisco Bay, and to develop recommendations regarding this matter. Dr. Williams will present his findings and recommendations at the Commission's April 3, 1986 meeting. The major conclusions of Dr. Williams' study are:

1. There is general agreement in the scientific community that significant changes will occur in the global climate due to the accumulation in the atmosphere of "greenhouse" gases, such as carbon dioxide, methane, and chlorofluorocarbons.
2. As a consequence of climatic change, there is general agreement that there will be an acceleration in the rate of sea level rise from the present rate of half a foot per century to between two and eight feet in the next century. Because there is considerable uncertainty in these estimates, the Environmental Protection Agency suggests the use of a middle-range estimate for planning purposes, which for San Francisco Bay would be about four feet in the next century.
3. A rise in sea level of about four feet would dramatically change the physical character of San Francisco Bay and the Delta. Assuming it would be economically feasible to maintain only those levees that protect urban development,

areas such as salt ponds, the Suisun Marsh, and the Delta islands would eventually fail. The area of the Bay/Delta system would then approximately double over the next century with the most dramatic change being the creation of an inland sea in the Delta.

4. This increase would have the following effects: (a) tidal circulation would change; (b) salinity would increase in Suisun Bay and the Delta; (c) sedimentation rates might be reduced; (d) wave action would be increased; (e) flooding of adjacent low-lying areas would be increased; (d) drainage would be impeded; (e) water quality could be improved unless toxic waste dumps are exposed; (f) navigation could be improved; (g) groundwater contamination would occur; and (h) salt marsh, brackish marsh, and seasonal wetland areas would be reduced.
5. The flooding of the Delta islands and consequent increase in salinity would drastically affect California's irrigated agriculture in the San Joaquin Valley and southern California's water supply.
6. Based on these probable impacts, there is a need for coordinated planning for flood control, environmental resource protection, and protection of Suisun Bay and the Delta.
7. In order to develop this planning effort, research needs to be carried out in the following areas: (a) defining the physical characteristics of the Bay in order to assess areas at risk; (b) analyzing sediment movement in the Bay; (c) developing flood protection standards; (d) analyzing the tidal hydraulics of the Bay; and (e) evaluating changes in salinity in the Bay and Delta.

Significant Rise in Sea Level Now Seems Certain

By ERIK ECKHOLM

MANY scientists are so sure that the sea level will rise visibly in the coming decades that they are advising planners to adopt new strategies now. A predicted rise in sea level of one foot within the next 30 to 40 years will drive much of the Atlantic and Gulf shoreline inward by a hundred feet and some of it by more than a thousand feet, according to marine geologists. The environmental and economic consequences will be felt much farther inland.

The loss of land to the seas "will create havoc on our shoreline," warned Orrin H. Pilkey, a marine geologist at Duke University. "Americans have been rushing to the coast, but much of our beachfront development has been contemptuous of natural forces."

Creeping waters will destroy buildings and roads, wipe out recreational beaches, escalate flood problems many miles inland, pollute community wells with saltwater and drown coastal marshes vital to fish and birds.

The rise in sea level will become even more pronounced a century from now, scientists predict. They say

that the sooner planners take account of the inevitable changes, avoiding investments in doomed facilities and protecting remaining wetlands from development, the lower the ultimate costs will be.

For the United States, those studying the threat describe it as more like an expensive irritant than an impending disaster. But in densely populated lowlands of some poor nations, they say, the effects could be catastrophic. Hardest hit may be Bangladesh, where the combined effects of rising seas and subsiding land over the coming century could obliterate as much as 10 percent of the crowded country, inundating vast tracts of fertile land and extending the deadly sweep of tidal waves.

Last week in Washington, a panel of experts convened by the National Academy of Sciences completed a report on the challenge of rising seas that will be published later this year.

The chairman of the academy panel, Robert G. Dean of the University of Florida, said the report is intended to "sensitize" shoreline communities, engineers and scientists to the likelihood of a significant rise in sea level so they can consider incorporating this into their planning. Coping with the accelerating rise "will require some difficult decisions," he said. "Do you try to save a structure or not?"

Most of the world's shorelines are already receding, according to geologists who estimate that the seas worldwide have climbed an average of about 4 inches over the last century. This is attributed to the slow melting of midlatitude mountain glaciers, still retreating since the last ice age. But the total change in sea level around the United States during the last hundred years has been greater, about one foot, because much of the country is gradually sinking even as the ocean rises.

In coastal states, the steady shrinkage of shorelines has already spawned a debate between those who advocate a strategic retreat from restless beaches and those more inclined to fight for valuable stretches

of shore by building sea walls and rock jetties and by "nourishing" eroding beaches with truckloads of sand. Often, the debate pits geologists, whose study is the sands of time, against engineers, for whom nature's infringements are a call to combative action.

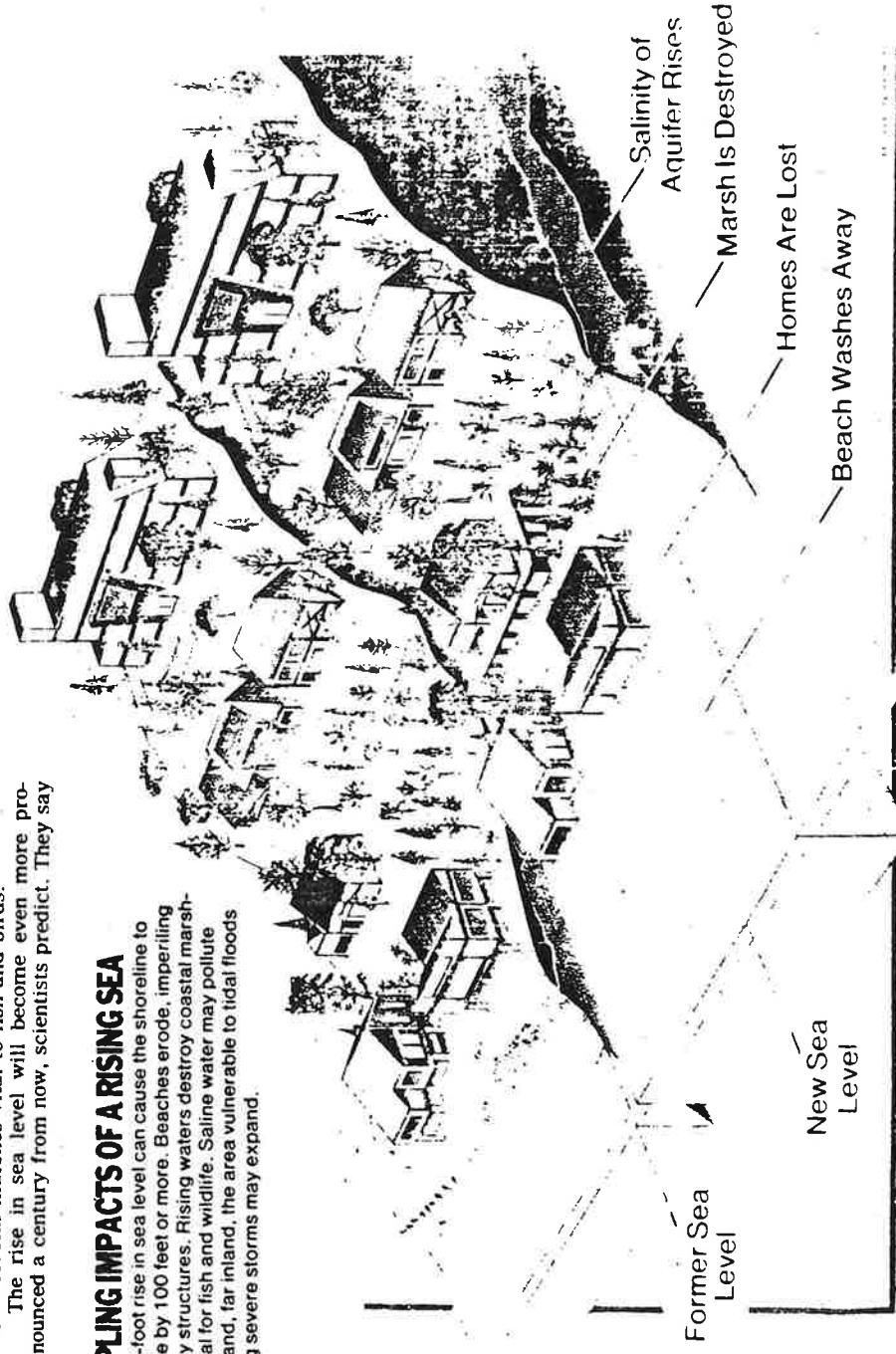
In the decades ahead, the climb of the world's waters will almost certainly speed up, according to leading scientists. Because of the impending global warming due to the greenhouse effect, more of the water locked in glaciers and, eventually, in the great ice masses of Antarctica and Greenland will melt. Almost as important, the oceans will also expand simply because they are warmer.

The greenhouse effect results from the increase in carbon dioxide and other gases in the atmosphere as a result of industrial activity. The gases

North Carolina and Maine have chosen to retreat from shore rather than fortify it.

allow sunlight to reach earth but absorb energy radiating outward, causing the atmosphere to warm. Scientists are nearly unanimous in predicting a global warming, but are uncertain about its pace.

(over)



RIPPLING IMPACTS OF A RISING SEA

A one-foot rise in sea level can cause the shoreline to recede by 100 feet or more. Beaches erode, imperiling nearby structures. Rising waters destroy coastal marshes, vital for fish and wildlife. Saline water may pollute wells and, far inland, the area vulnerable to tidal floods during severe storms may expand.

Sea Rise Seems Certain

Continued

Five-Foot Rise in Century

A decade ago the specter of disaster was evoked by scientists who feared that warming oceans would cause the massive ice sheet of western Antarctica to disintegrate, quickly boosting the seas by 15 feet and flooding major cities. Today most experts believe this is unlikely within the next century or two, and predict that changes in weather patterns will be the most troublesome result of the global warming. Even the revised estimates of oceanic rise, however, spell serious problems for many countries, they maintain.

According to recent calculations by the Environmental Protection Agency, the sea level around much of the United States will climb by one foot over the next 30 to 40 years and by three to five feet over the next century, according to James G. Titus, who directs the agency's research on the problem. These estimates include the effects of the gradual subsidence of land, which is about eight inches per century along the eastern coast.

Other estimates are somewhat lower but still worrisome. A 1983 report by the National Academy of Sciences, for example, predicted a global rise in sea level of about two and one-third feet by 2080, not including the effects of land movements.

When the coastal plain is gentle, as along most of the Atlantic and Gulf coasts of the United States, a given rise in the water level can push in the shoreline hundreds, even thousands of times that distance. The adjustments tend to come in erratic spurts, especially during large storms when a barrier island may roll landward, or a bank of sand dunes may wash away, never to rebuild itself.

Hazards Apparent on Long Island

The hazards of shoreline development are already apparent in eastern Long Island, where the beaches are retreating an average of one foot a year. "There's no question that the sea is rising on Long Island," said Larry R. McCormick of Southampton College. "As it continues to rise, beaches will grow narrower and narrower and decline in number. The response will be construction of more and more hardening structures to protect homes."

Louisiana's shore is receding faster than that of any other state. Largely because of the rapidity with which the Mississippi River delta is compacting, the state's level relative to the sea is changing by four-tenths of an inch per year. This translates into losses of 50 square miles of land per year, according to Dag Nummedal, a geologist at Louisiana State University.

The state has embarked on a controversial \$40 million program to stabilize its coast, and not just out of concern for the swamplands being engulfed. "For every inch of land Louisiana loses, they lose an inch of offshore oil rights," Dr. Pilkey noted. "It's a gut economic issue for them." The state's rights to a share of oil revenues end exactly three miles offshore.

In addition to eroding the shoreline, a rise in sea level can boost the frequency and extent of coastal flooding due to storm surges, the devastating high tides driven in by hurricanes or severe storms. Salt water will intrude on aquifers that provide drinking water for some coastal communities, and saline water will reach farther up rivers. Some abandoned toxic waste sites may become turn into swamps or be flooded, creating health hazards.

Rising waters, changing flood patterns and saltwater intrusion are likely to destroy huge coastal wetlands, which provide crucial underpinnings for much fish and bird life. The future rate of sea level rise will far outpace the rate at which wetlands can reform naturally, experts say, and in any case many of the nation's dwindling coastal marshes are already hemmed in by homes or shopping centers.

In Louisiana, Dr. Nummedal observed, salt marshes that were nursery grounds for shrimp and fish are becoming open water, while farm fields are turning into salt marshes; wetlands survive, but at the cost of agriculture.

Steps to Take Right Away

While all scientists agree that more research on the future sea level is needed, many argue that it is not too early to begin factoring the predicted change into planning. "Thousands of individual decisions will make better sense in the long run if people take account of the rise in sea level," said Dr. Titus of the EPA. "There are constructive things we can do, often with little or no extra expenditure."

For example, Dr. Titus said, a coastal community might design a new drainage system differently with knowledge that a higher sea level is in store, avoiding major future expenses. Zoners might declare vulnerable areas a nature reserve, preventing ill-fated development. A decision might be made to clean up rather than seal off an abandoned toxic waste dump that is likely to be inundated a few decades from now.

Studies are just beginning on the international implications of the rising sea level. Scientists at the Woods Hole Oceanographic Institute are examining the likely environmental and economic effects on the heavily populated, sprawling deltas of five major rivers in Africa, Asia and Latin America, some of which, like Louisiana, face the dual threats of rapid land subsidence and a rising sea level.

These areas, surrounding the mouths of the Ganges in Bangladesh, the Indus in Pakistan, the Yangtze in China, the Nile in Egypt and the Magdalena in Colombia, tend to be low and flat. The combination of subsidence and rising seas "could mean the loss of a tremendous amount of land either to submergence or erosion," said John B. Milliman, a marine geologist at Woods Hole. Preliminary findings indicate that the expected change in relative sea level in Bangladesh over the coming century may destroy more than 10 percent of the country's land, this in a country that is badly overcrowded today. In addition, groundwater will become

more saline, killing off mangrove swamps and cutting the productivity of estuaries.

"It goes on and on, a litany of things you don't want to happen," Dr. Milliman said of the possible impacts in Bangladesh.

Managing Coastal Development

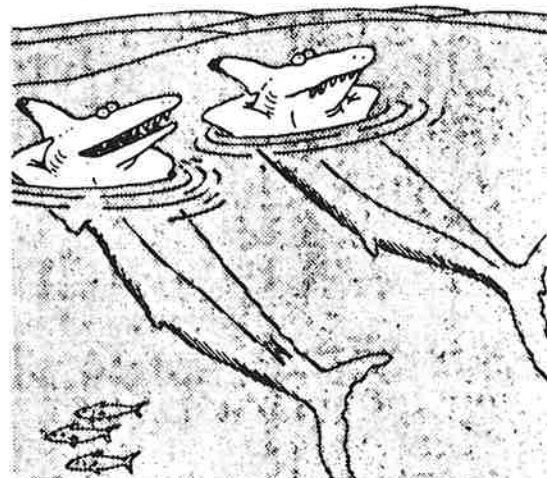
Meanwhile, in the United States, the debate continues over how best to manage coastal development. Dr. Pilkey, who can cite many examples of self-defeating efforts to stabilize beaches, champions the "retreat" approach. He praised the states of North Carolina and Maine, which he said "have basically opted to retreat from the shoreline," prohibiting permanent buildings or protective structures on threatened beaches.

"I don't see retreat as a uniformly applicable response," Dr. Dean replied. "Often it will boil down to economics."

Where the population is sparse or the encroaching forces of nature are great enough, he said, then retreating, as by designating an area a park or preventing reconstruction after storm damage, makes sense. But in areas with a high tax base, fighting the sea can pay off, said Dr. Dean, who, in addition to his academic work, directs Florida's division of beaches and shores. He cited the restoration of sandy beach along a 15-mile stretch in Miami Beach, Fla., which cost \$65 million but has generated many times that in tourist revenue, as a "model."

The "retreaters" do not deny that stalling actions are often feasible, but warn that the costs will be high and continuing. As an example of the scale of effort that can be required to check encroaching waters, some point to Holland, which has claimed large areas from the sea by building dikes and draining land that is below sea level.

"In Holland," Dr. Nummedal observed, "they spend a larger percentage of their gross national product on defense of their coasts than the United States spends on military defense."



"Gee, that's a wonderful sensation. Early in the morning, you just woke up, you're tired, movin' kinda slow, and then that ooold smell hits your nose... blood in the water."

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION
30 Van Ness Avenue, San Francisco 94102 557-3686

October 22, 1971

TO: All Commissioners and Alternates
FROM: Joseph E. Bodovitz, Executive Director

SUBJECT: MEASUREMENTS OF THE SIZE OF SAN FRANCISCO BAY

NEW MEASUREMENTS

A recent study by the U. S. Geological Survey* contains the most accurate figures yet compiled on the present size of San Francisco Bay and the extent of past filling and diking. The staff believes these figures should be accepted by BCDC to replace the figures now being used in BCDC publications.

The new USGS figures are:

San Francisco Bay System Including
San Pablo and Suisun Bays**
(square miles)

	<u>About 1850</u>	<u>1968</u>	<u>Change</u>
Water areas, up to the beginning of marsh vegetation	474	421	- 53 (-11%)
Marshlands, including marshes along sloughs and channels less than a half-mile wide	313	127	- 186 (-60%)
 TOTAL BAY SYSTEM	<u>787</u>	<u>548</u>	<u>- 239 (-31%)</u>

The figures that have been previously used by BCDC were compiled in 1966 from several sources, including studies made for the Army Corps of Engineers. These figures, which have been cited in BCDC publications, are:

	<u>About 1850</u>	<u>1968</u>	<u>Change</u>
TOTAL BAY SYSTEM	<u>680</u>	<u>400-420</u>	<u>- 260-280 (-36-41%)</u>

* Nichols, D. R., and Wright, N. A., Preliminary Map of Historic Margins of Marshland, San Francisco Bay, California, U. S. Geological Survey.

** Corrected to exclude area beyond line of Commission jurisdiction, Stake Point-Simmons Point at the east end of Honker Bay.

The differences between the USGS figures and the figures previously compiled for the BCDC planning program are due in part to revised measurements of the presently-remaining marsh areas and in part to measurements of the water area between mean sea level and mean high tide. The new figures thus indicate that the amount of salt marsh remaining around the Bay is about 125 square miles, compared with earlier estimates of about 75 square miles.

In brief, the new USGS figures show that the exact size of the Bay in about 1850 was somewhat larger than originally estimated, the exact size of the remaining Bay is larger than originally computed, and the amount of the Bay system lost through diking and filling is about 31%, compared with earlier estimates of about 36-41%.

STAFF RECOMMENDATION

The staff recommends that the Commission accept, and use in all future reports, the new USGS estimates of the size of the Bay, as part of the Commission's continuing effort to keep the Bay Plan up to date on the basis of all new research and information.